INDIVIDUALS OF STRATIGRAPHIC CLASSIFICATION: DISCUSSION.

THE exceedingly suggestive paper appearing in a recent number of the JOURNAL,[1] under the above title, brings up for discussion some of the very practical problems which confront the geologist in his daily work. Their importance will perhaps warrant a supplementary discussion of the subject from the point of view of the mining geologist; not that this is necessarily the most important point of view, but rather that geologists in their devotion to the interests of pure science are apt to overlook the needs of fellow workers in applied science. The debt of science, as expressed in the generous appropriations of the various states and the general government for geological surveys and similar institutions, is too great to warrant us in failing at any time to give the highest possible return in practical results. While the great purpose of geologic science, to reconstruct the past history of the earth, must be kept steadily in view, it is well, if we would have the means to carry on that work, that we should keep no less steadily in view the wants of the plain citizens who are developing our country's resources.

The paper in question is particularly welcome to the mining geologist because it emphasizes the importance of mapping many of those features which will help him most in directing the development of mines and mineral deposits. One engaged in such work needs somewhat more complete data in regard to the lithology of the rocks and the geographical distribution of the more minute rock units than are necessary for ordinary geological research. He needs also a very minute knowledge of local structure and as perfect a knowledge as may be of the processes of change through which the rocks have passed.

In studying the genesis of any ore deposit it is needful, first,

[1] BAILEY WILLIS, *Individuals of Stratigraphic Classification*, JOUR. GEOL., Vol. IX, No. 7, October-November, 1901, pp. 557–69.

to determine, if possible, the exact conditions under which the country rock was laid down, so as to know what the original content of the rock in mineral is likely to have been. Since the conditions under which deposits accumulate are reflected in the character of the material accumulated, lithology is of primary importance at this stage of the investigation. In the second place it is important to determine the changes which the rock has undergone since its original formation. This at once leads into the general study of metamorphism, and again the expression of the results is best accomplished by lithologic mapping. Since, however, different materials under the same or different processes of metamorphism may produce rocks which in their final stages are lithologically identical, a map to express the full facts must be constructed so that by means of various colors, patterns, symbols, or prefixes in the legend, the lithologically similar but historically different rocks may be readily distinguished. The structure of the region must be thoroughly understood before any general plan of development can be formulated. All these facts can and should be represented upon any geological map intended for the use of a mining population.

In general the mining geologist is called upon to do two things: (1) to report upon some mine or tract of presumably mineralized land in order to determine whether the showing warrants the undertaking of development work; (2) to direct the further development of mines already partially opened up. In reporting upon properties he is oftenest sent to regions which are very little developed and which generally are not geologically mapped. In such a region he must rely in the first instance upon such reconnoissance maps as may be available, but in the main upon his own efforts. In the nature of the case the first detailed mapping in mineral districts must in a majority of instances be the result of individual initiative. The maps made in this way are more detailed than official maps can be expected to be, but they are also entirely unrelated, and each covers a very limited territory. So far, then, as the primary develop-

ment of mineral districts is concerned, reconnoissance maps are the best that can be rightly expected by the mining geologist. For his purpose it is more important that he should have such maps of the whole country, and that such facts as are represented on them shall be accurate, than that they should show great detail. For example, if such a map shows the presence of limestone and porphyry, together with a structure generally similar to that of the Leadville district, he will feel warranted in having prospecting undertaken within the area. The exact distribution of the limestone and porphyry areas is a very minor consideration, and errors in this particular will not greatly injure the usefulness of the map. A mining company must always make independent and careful surveys in any event in locating and patenting the property.

Since it is generally true that rocks of the same age are apt to bear the same or related minerals, any suggestion as to the age of the rocks becomes immensely helpful. If the age is in doubt the fact can be indicated by a question mark in the legend, but even a guess is helpful in suggesting the thought of one who has studied the territory more widely than is possible to one working against time to select the best locations in a given district.

There is apparently a growing sentiment against reconnoissance and general maps. This is unfortunate if the interests of the miner are to be taken into account. It is true that such maps must in the nature of things be not only incomplete but inaccurate. Yet they are the maps which in nearly every case are used in the development period of a mining camp, and in making them the geologist does the greatest service, quantitatively at least, to the mining industry that he is capable of. It is impossible to make an accurate and serviceable geologic map of a mining district, such as the maps of the Telluride and Butte folios of the United States Geological Survey, in advance of a certain amount of mining development. Such general maps, however, as are found in the Hayden *Atlas of Colorado* can be made readily and at comparatively low cost. They are at once avail-

able and serviceable. In the present oil development at Boulder, Colo., the Hayden map has been of the highest service. No doubt a more detailed map would be much better, but upon the Hayden base each oil expert can make a map of his own. If the investor were to wait until a proper map could be made by government or state officials, he would find the best territory all pre-empted and drilled.

So far, then, as helping in the development of new mining districts is concerned, it should be the first duty of the geologist to furnish good reconnoissance maps giving general data regarding (1) lithology, (2) structure, and (3) age. In spite of the limitations and inaccuracies of such maps their tremendous usefulness is sufficient warrant for their production.

I would not be understood as decrying the making of detailed maps. By no means. Let us have as many of such maps and as much detail as possible; but let us have first the reconnoissance maps and later, after the prospector and miner have developed a few good properties and opened up the ground enough to enable the geologist to get a right understanding of the structure and the ore bodies, let as detailed a map as possible be made. Such a map will be of the highest service in the development of a general plan of operation; the laying out of long cross-cut tunnels or the locating of deep shafts. Studies of the genesis of the ores made at the same time will indicate the probability as to the permanence of the ore bodies and give a reliable answer to the question of the erection of large permanent works, the building of railways, smelters. etc. In the beginning of mining operations these questions do not need to be answered. It is fortunately true that the initial operations are nearly always small and individual. It takes time to interest capital, to reconcile conflicting interests, and to bring about the economic conditions necessary to operations on a large scale. During the interval the general map is sufficient. There are no large works to be planned and it would be impossible to carry them out if there were. When, however, the

development of a camp has reached a stage where these questions arise, no map can be too detailed to be serviceable. In making such a map all available facts bearing on the original condition of the rocks and the subsequent changes they have undergone should be shown as far as possible.

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